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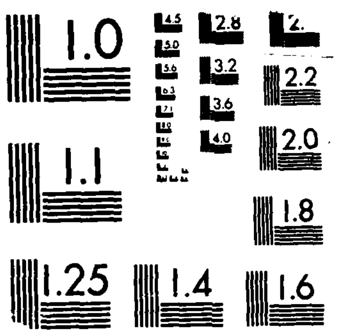

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HUMAN RESOURCES

THE ROTATION AND ASSIGNMENT OF IMBALANCED AIR FORCE SPECIALTIES: A POLICY ANALYSIS MODEL

Thomas D. Clark, Jr., Lt Col, USAF

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A dynamic model of a complex multi-echelon personnel system is presented in this paper. The system manages United States Air Force airman assignments in critical specialties. Some of these specialties are imbalanced, with more personnel required overseas than can be supplied and still allow airmen sufficient-tour-length assignments in the continental United States. The model deals with inputs and outputs of personnel at the organizational level and provides a mechanism for testing the effects of alternative policies on system performance. A discussion of the advantages of the methodology over other techniques for this type of analysis is included.

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SUMMARY

A dynamic model of a complex multi-echelon personnel system is presented. The system manages United States Air Force airman assignments in critical specialties. Some of these specialties are imbalanced, with more personnel required overseas than can be supplied and still allow airmen sufficient-tour-length assignments in the continental United States. The model deals with inputs and outputs of personnel at the organizational level and provides a mechanism for testing the effects of alternative policies on system performance.

The research methodology used, system dynamics, illustrates its advantage in such analysis over alternative procedures (static Markov or entity simulation models). It provides an example of how complex flows through a variety of interconnecting levels can be modeled and how the model can be used in policy analysis. With such models, problems that arise in the system can be traced to their causes, and structural changes that would alleviate problems can be investigated and quickly tested.

A test of the analytic capabilities of the model was conducted on current policies which advocate converting military to civilian positions for jobs when vacancies arise. Test results indicated that a larger military force in the continental United States is required. Conversion policies may not be the best for overall system performance. Policies which alter tour lengths or make minor changes in bonuses paid seem to have little effect on system performance. Those that expand the rotation base lead to the most favorable behavior.

PREFACE

The work described in this article was accomplished while the second author was attending the Air Force Institute of Technology at Wright-Patterson AFB, Ohio. The views expressed are those of the authors and do not necessarily reflect official policy of the Air Force or the Department of Defense.

Keywords: decision making, manpower/human resource planning, military assignment, organization, policy management, system dynamics

The rotation and assignment of imbalanced air force specialties: A policy analysis model

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ABSTRACT

A dynamic model of a complex multi-echelon personnel system is presented in this paper. The system manages U.S. Air Force airman assignments in critical specialties. Some of these specialties are imbalanced with more personnel required overseas than can be supplied and still allow airmen sufficient tour length assignments in the continental United States. The model deals with inputs and outputs of personnel at the organizational level and provides a mechanism for testing the effects of alternative policies on system performance. A discussion of the advantages of the methodology over other techniques for this type of analysis is included.

INTRODUCTION

Personnel flow structures in organizations generally are planned and managed with a set of policies that determines recruitment rates, career development, and retirement. Analysis of such systems has been approached with a variety of techniques, most of which ignore these personnel policies. The analysis technique discussed in this paper focuses on the policies that determine the flows of personnel and provides a method to show how the policies are imbedded in a complex informational feedback structure. System dynamics techniques are used as a method of simply representing the structure of such systems and as an alternative management technique.

The example discussed in the paper is from a segment of the personnel management system of the U.S. Air Force and deals with the rotation of military personnel assigned to specialties in which there are a large number of overseas tours relative to the number of tours within the United States. The structure of the system presents problems for individuals in those specialties and for decision makers who must manage those specialties. Retention rates are reduced when there is a high frequency of overseas tours in a given military specialty. Lower retention results in higher costs to move and replace people, in an undesirable mix of experienced and inexperienced people, and in a subsequent decrease in force readiness. Specialties with a large number of overseas tours are typically referred to as imbalanced career fields.

Typically, the other techniques used for manpower planning have been static Markov models or entity simulation models. Markov models generally assume the probability of changing states depending only on the current state, and not on how that state was reached.[6] Transition probabilities are fixed and

are usually computed using cost function or production function. This objective function is usually assumed to be linear and the transition rates or flow rates are generally considered constant throughout the run of the model. Manpower systems are modeled as static, equilibrium systems.[1,5,7,15]

Entity simulation models require a one-to-one correspondence between entities in the model and the reference systems being modeled. Such models of manpower systems generally contain a large number of source lines of some high-level language, require an extensive data base, are difficult to modify in terms of model structure, and the questions of verification and validation are seldom addressed. Sensitivity analysis has been limited to studying the effects on model results due to changes in the input parameters. The "client" or user of the model has had to assume that the model builder's assumptions of the model structure were correct and would result in valid model behavior.[5,11,15] The example in the paper illustrates the parsimony of system dynamics models in comparison to entity simulation models.

PROBLEM STRUCTURE

The assignment and rotation system for imbalanced Air Force career fields has associated with it an internal and external environment. The internal environment is similar to all personnel systems and includes the perceived need for overseas personnel, the reaction of policymakers to the perception, the national labor market, and the problems and needs faced by the branches of the armed forces. System performance is a function of how well various policies control the system as the forces and flows in each environment interact. The forces and flows create informational feedback structures that require analysis techniques which address the many interacting components that affect system performance. It is important for decision makers to have an explicit conceptualization of the system in which particular problems exist. A dynamic representation of the system is necessary for such an understanding to be achieved. This representation in a format that can be treated dynamically with a parametric model is a strength of the system dynamics approach.

The system dynamics approach[2,10,13] to analysis views systems as forming closed-loop feedback systems. The use of the word "system" in the system dynamics context indicates a "wholeness of perspective – a system approach – which one attempts to achieve for a given problem."[12] This method was chosen because of its ability to represent the feedback structures and continuous flow nature of typical personnel systems. Other advantages of the approach include the following:[7]

(1) The approach is simple and easy to understand.

(2) The approach is comprehensive and includes the steps of verification and validation.

(3) System dynamics models lend themselves to simple structural changes.

(4) The programming of formal models is eased through the use of DYNAMO[9] (a continuous simulation language based on difference equations).

(5) The cost of computer operations is relatively low.

(6) Long-term consequences are emphasized.[1]

(7) System dynamics models are continuous.

(8) The approach demands the involvement of the decision-maker(s).

The computer simulation model that resulted from application of the method explains how the interactions in the military rotation system produce wide fluctuations in the population levels in jobs within the United States and in the population of first-term airmen. Also explained are the observed problems related to: (1) overmanning of first-term airmen, (2) shortages of second-term and career airmen, (3) "overshooting" the total manning level for a given year following a total manning shortage in previous years, and (4) the objective of minimizing family separations.[14] These fluctuations and behavioral problems have spawned policies to control first-term/career mix, civilian/military substitutions, costs due to frequent rotational moves, costs due to replacement of personnel, and potential decreases in force readiness. The analysis in this study was directed at understanding the problems and testing various candidate policies for their solution.

CAUSAL RELATIONSHIPS

A person studying a system forms a mental model of its structure. In the system dynamics approach, such models initially are formed as causal-loop diagrams.[6] The causal-loop or influence diagram is used during the early stages of a study to express the cause and effect relationships and feedback structure which form the basis of a dynamic system model.

A high-level causal structure of the rotation and assignment system is shown in Figure 1. The representation shows the interdependence and interrelationships of portions of the system, but only suggests the components that affect system performance at a more detailed level. The diagram is interpreted by asking the question: If a variable "a" increases, what happens to variable "b"? The + or − sign at the head of the arrow indicates the hypothesized answer. In the course of system study, the modeler validates the originally hypothesized answer.

There are several feedback loops shown in the figure. For example, as the number of people in any of the individual skill levels within the Air Force Specialty (AFS) increases, the total number of people in the specialty increases. As the total increases, the disparity between the actual number and the number required will decrease, which decreases the perceived need for more people in the specialty. As the perception of total manning need increases, so does the perceived need to increase pay and compensation with which to retain the currently existing force. Pay and compensation, which can take the form of salaries paid, military benefits, and bonuses paid to individuals in a given career field, are major components of system cost. An increase in the perceived manning required also causes an increase in perceived need for accessions. People can be accessed from the civilian population through technical school training or laterally from other career fields in the Air Force through cross-training or transfer. As both of these accessions go up, system cost increases to reflect training expenditures. System cost also is affected proportionally by changes in pay and compensation. As the number of accessions increases, the total number of people in the specialty increases.

Initial development of the causal structures was completed using material from personnel working within the airman assignment and rotation system and from DOD literature in the areas of retention and rotation. As the study progressed, the original causal conceptualization of the system was divided into three major sectors: (1) a Personnel Fill Sector, (2) a Rotation Sector, and (3) a Manpower Authorization Sector. The Personnel Fill Sector is concerned primarily with maintaining the proper number of people in the career field. The Rotation Sector is

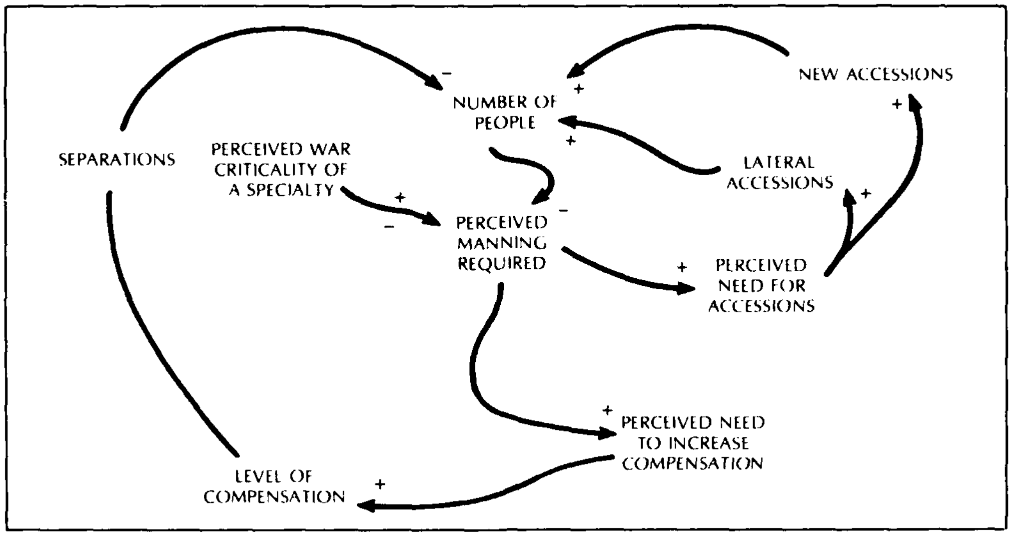

Figure 1. System interrelationships.

concerned with maintaining the desired population levels in overseas and stateside tours. Factors common to the Personnel Fill and Rotation Sectors include the number of people in the career field, the dissatisfaction due to frequent rotation, and system costs due to the moves, training, pay and compensation, and bonuses. The components and interactions of these two sectors will be discussed later, using a more detailed causal loop diagram. The Manpower Authorization Sector is concerned with the proper number and distribution of manning positions to achieve given requirements and may be considered as a constant for the purposes of this research. Its effects are included through the "desired" population levels shown in the other sectors.

Figure 2 shows the detail of the skill progression ladder and related components of the Personnel Fill Sector. The skill levels of personnel within the system denote the experience level, with Skill Level 3 (SL3) personnel having the least amount of experience and Skill Level 9 (SL9) personnel having the most experience. SL3 personnel are typically young airmen with less

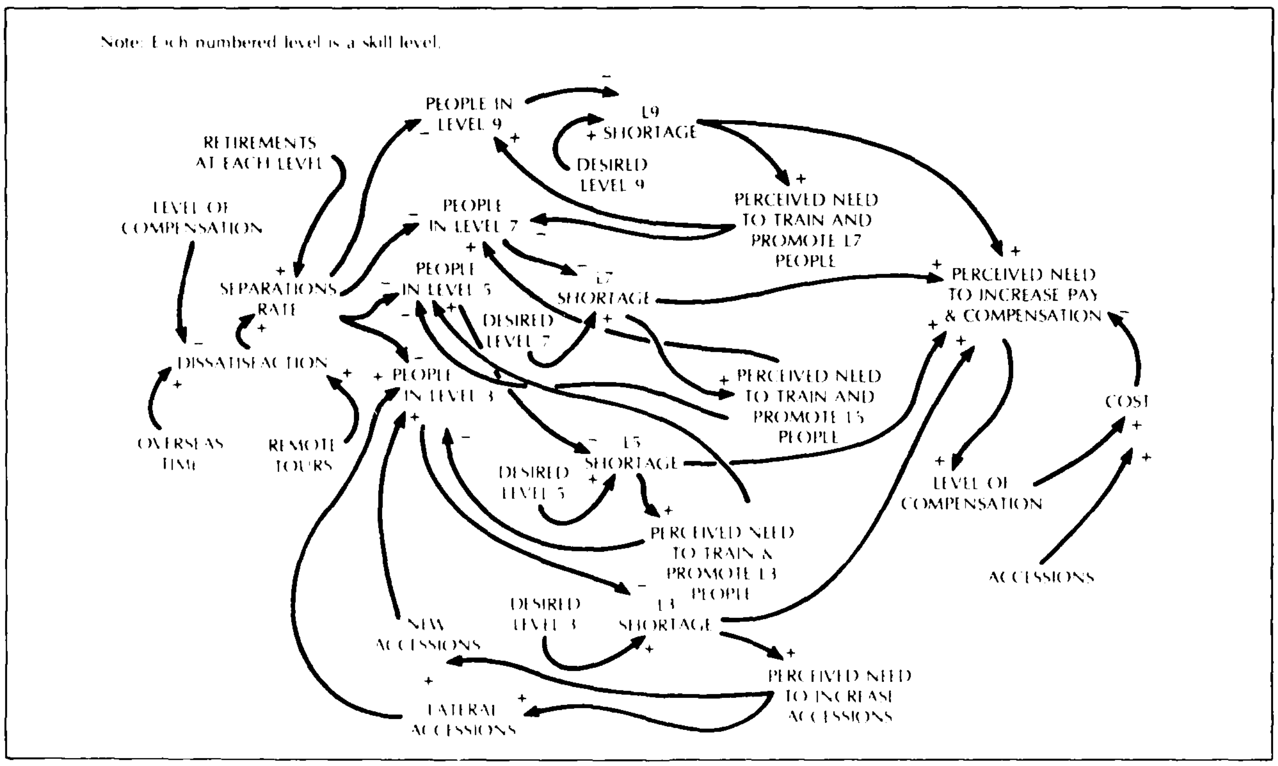

Figure 2. Personnel Fill Sector causal structure.

than four years of experience. Skill Level 5 (SL5) personnel usually have between four and eleven years of experience, and Skill Level 7 (SL7) and SL9 personnel serve primarily in supervisory positions.

Beginning with the perceived need to increase accessions, an increase there causes an increase in new and lateral accessions. As those accessions increase, the number of people in level three increases. As the number of people in SL3 increases, the SL3 shortage decreases, which causes a decrease in the perceived need to increase accessions. This is a goal-seeking or negative-feedback loop which depicts how personnel enter the system. Behavior and movement within the system are driven by the need for people in higher skill levels. For example, as the number of people in SL9 decreases, the SL9 shortage increases. As that shortage increases, the perceived need to promote from below (the only place from which to draw to make up the shortage) increases. As the perceived need to promote increases, the promotions increase and the number of people in SL7 will decrease. This process continues down the ladder for SL7 drawing from SL5, and SL5 drawing from SL3.

At all skill levels, as the number of people increases, so too will the separation rate for retirements. Retirements most affect movements in the higher level skills. As separations increase, the number in the skill level will decrease. Separations at the lower skill levels are affected most by member dissatisfaction with the level of pay and compensation and with unfavorable rotation rates.

The Personnel Fill Sector is connected to the Rotation Sector through cost increases as the number of moves increases. Figure 3 contains a causal representation of this sector. Overseas assignments fall into two major categories: (1) overseas long tours, and (2) overseas short or remote tours. People rotate from the continental United States to overseas and remote areas and back.

As the number of people overseas increases, the number of people making return moves increases. As the number of people leaving overseas increases, the shortage of people overseas increases, the perceived need for people overseas increases, and the number of moves from the United States to overseas eventually increases. A similar causal flow exists for remote assignments. For both flow subsystems, certain factors associated with moves cause individual dissatisfaction to rise and fall. The components of the dissatisfaction stemming from rotation are the time spent in the United States between remote assignments, the average number of remote assignments a person experiences in a career, and the average time spent remote and overseas in a career. As dissatisfaction increases, the individual skill level separation rates in the Personnel Fill Sector increases.

The Rotation Sector models how people move from assignment to assignment and how well the personnel achieve the goals of minimum dissatisfaction stemming from rotation, minimum system cost, and 100% manning of remote and overseas requirements. This sector supplies the Personnel Fill Sector with dissatisfaction and cost measures. The Personnel Fill Sector models personnel movement within the specialty and the tradeoffs between manning efficiency and cost.

Inexperienced people are accessed into a specialty primarily from the civilian population, with a small percentage being accessed through lateral moves from other specialties. Over time, people progress to higher skill levels and make decisions about separation. The primary factors that influence separation rates are pay and compensation amounts, bonuses, dissatisfaction with rotation, and the national economy. Assignments to different world locations are given to members of a specialty on a first-in, first-out basis with volunteers having priority. People assigned to tours in the continental United States form the rotation base from which assignments to overseas and remote areas are made. The size of this rotation base in relation to the desired number of overseas and remote assignments is the primary determinant of the frequency of assignment to overseas and remote areas for individuals within a given Air Force specialty.

MODEL STRUCTURE, BEHAVIOR AND OPERATION

The relationships depicted in the causal diagrams have been combined into a dynamic simulation model of the airman assignment and rotation system. Model verification and validation were addressed by applying the confidence-building tests

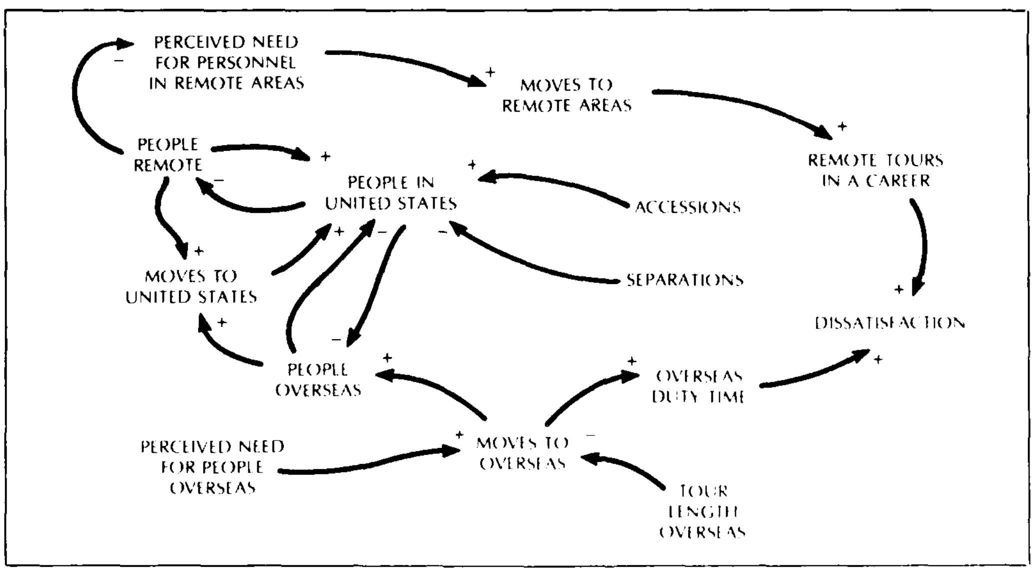

Figure 3. Rotation Sector causal structure.

developed by Forrester and Senge.[2,3,4] Forrester and Senge defined model testing as "the comparison of a model to empirical reality for the purpose of corroborating or refuting the model."[3] In this case, empirical information may include numerical statistics, descriptive knowledge of system structure, and observed system behavior. This section contains a brief description of the testing procedure employed. A documented listing of the model is available from the author.

The model is written in the standard system dynamics format. The feedback structures are implemented through a series of level and rate equations. The levels are accumulators. In this system, major levels are each skill level population and the total people in the continental United States and overseas. The rates control the input and output of the levels in each increment of model time.

The first series of tests performed were tests of model structure, which "assess structure and parameters directly without examining relationships between structure and behavior."[3] These tests were performed continuously throughout the development of the model. The first test of model structure consisted of structure verification, or of comparing the structure of the model directly with the structure of the references sytem being modeled. Implicit in the model structure were the system goals and their priority, the movement of personnel into and out of the major levels in the Personnel Fill and Rotation Sectors, the calculation of dissatisfaction stemming from rotation, and the effects of dissatisfaction, pay and compensation, and bonuses paid on separation rates. Individuals who manage the system were shown the model's structure and questioned about its authenticity and completeness. They supported its configuration.

The latter point is critical. Perhaps the most important element in developing a useful policy analysis model is to have it understandable to managers. This goes beyond simple structural verification, for the model must parallel executives' intuitive thought processes about the management of complex information feedback (causal) structures. The system dynamics technique requires managers to play an active role in model development and provides a method for rigorous analysis at senior executive levels.[8]

Another aspect of structure verification is the level of detail used in the model (boundary-adequacy). For example, skill levels and not individual military ranks within those skill levels were modeled. This level of aggregation was chosen since system behavior regarding major population trends could be traced with this structure. Further disaggregation would have added little in addressing the questions explored in the research. Similar choices were made for all the major levels in the model.

A second test of model structure is the parameter-verification test.[1] This test examines whether or not the model constants are consistent with observations from the reference system. Model data, such as skill level populations, overseas and remote authorizations, and the lengths of overseas and remote tours, were obtained from the current system information. Other values were obtainted by data gathered from individuals within the system. Sensitivity testing of parameter values showed their consistency and behavior over plausible ranges.

Two other tests of model structure performed were the extreme-conditions test and the dimensional-consistency test.[1] The second test is performed to insure the units on the left side of equations are consistent with reality and yield the mathematical functions on the equation's right side. The first test involves examining the plausibility of each rate equation when imaginary minimum or maximum values of the level variables are employed. When this test was accomplished, the behavior of each rate equation over time was tracked. As a result of the test, several rate equations were reformulated to prevent unrealistic behavior in the levels containing skills.

A second series of tests examined the model behavior. Included in the tests of model behavior were those dealing with behavior reproduction, behavior anomaly, surprise behavior, extreme policy, and behavior sensitivity. The behavior reproduction test was primarily concened with reproducing the symptoms of the airman assignment and rotation system outlined earlier in this paper. Using fiscal year 1982 data for the telecommunications system and equipment maintenance specialist, the model was run for 15 years. Figure 4 illustrates that the skill level plots from the model react as the actual system levels have. Skill Level 5 is undermanned while Skill Level 3 is overmanned. Most of the "fluctuation" in manning is absorbed in Skill Level 3.

Figure 5 illustrates that the population levels for continental United States, overseas, and remote tours also behave as the levels within the reference system. The level for the continental United States shows a good deal of fluctuation, whereas the remote and overseas levels are constant and only slightly below their desired manning levels. At the start of the simulation, there is an initial force shortage of 20 people. The shortage is quickly alleviated by increasing the Level 3 accession rate. Due to the delay, the number of people in the pipeline causes a slight overshoot in the total manning level. The primary behavioral symptoms were reproduced.

The results of the other behavior tests indicate that hypothetical formulations involving slight changes in bonus payments or in tour lengths for overseas jobs have a neutral effect on the system performance, and that any increases in the number of remote jobs have a negative effect on system performance. With confidence that the model behaves properly, the next step is investigation of policies that will satisfy personnel managers' objectives. Our purpose here is to illustrate use of the model as a policy analysis vehicle. Figures 6 and 7 illustrate the behavior of the skill levels and the rotation levels when the desired number in the skill levels is increased by about 15%.

This policy has two components. First, the remote and overseas allocations are held constant, implying that the number of allocations within the United States must be increased. Second, the increase in skill level allocations created immediate shortages in all the skill levels and in the total force. Figure 6 shows Skill Levels 5 and 7 increase steadily to higher values. Although Skill Level 3 shows an immediate reaction to the shortage, the Skill Level 3 population shows less fluctuation or less turnover in later years of the simulation. The decreased fluctuation is reflected in Figure 7 in the stateside population level for years 6 through 15. The advantages of increased stability are decreased system cost stemming from fewer moves and lower training costs, an improved first-term/career ratio, less dissatisfaction due to rotation, and increases in force readiness stemming from a more experienced and stable force. Other investigations into the model reaction to current and potential policies indicated that the model was valid in its ability to reproduce behavior and predict anticipated behavior for the parameter and constant values chosen.

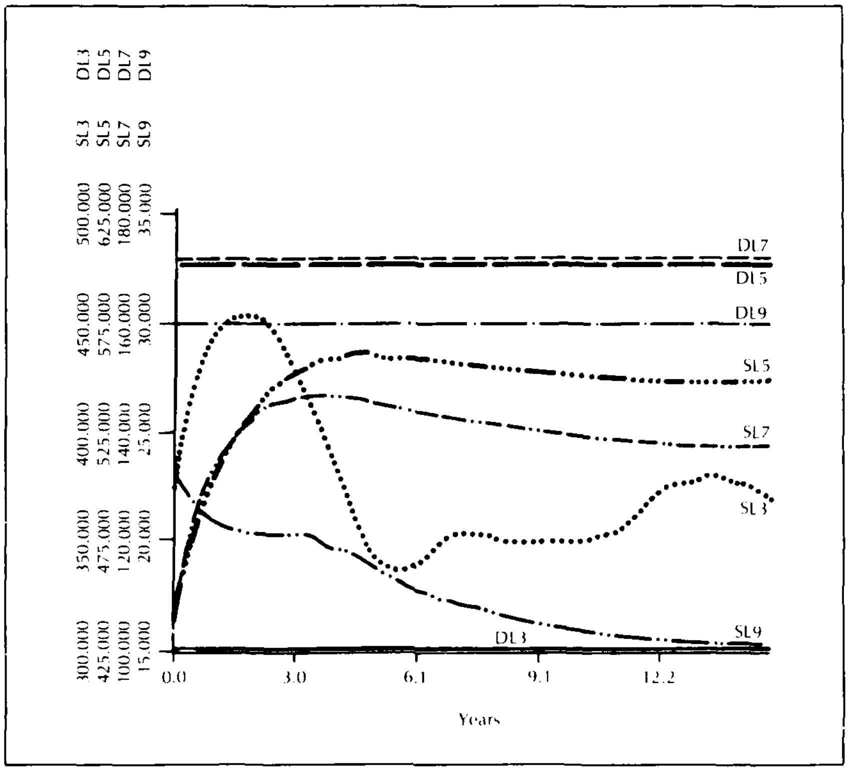

Figure 4. Base run: Personnel Fill Sector levels.

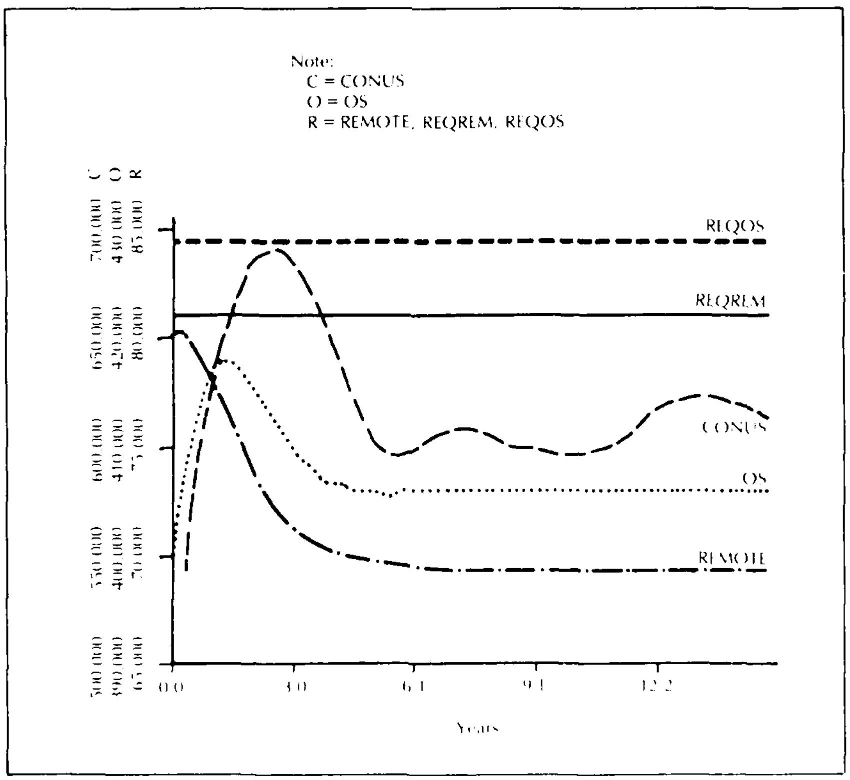

Figure 5. Base run: Rotation Sector levels.

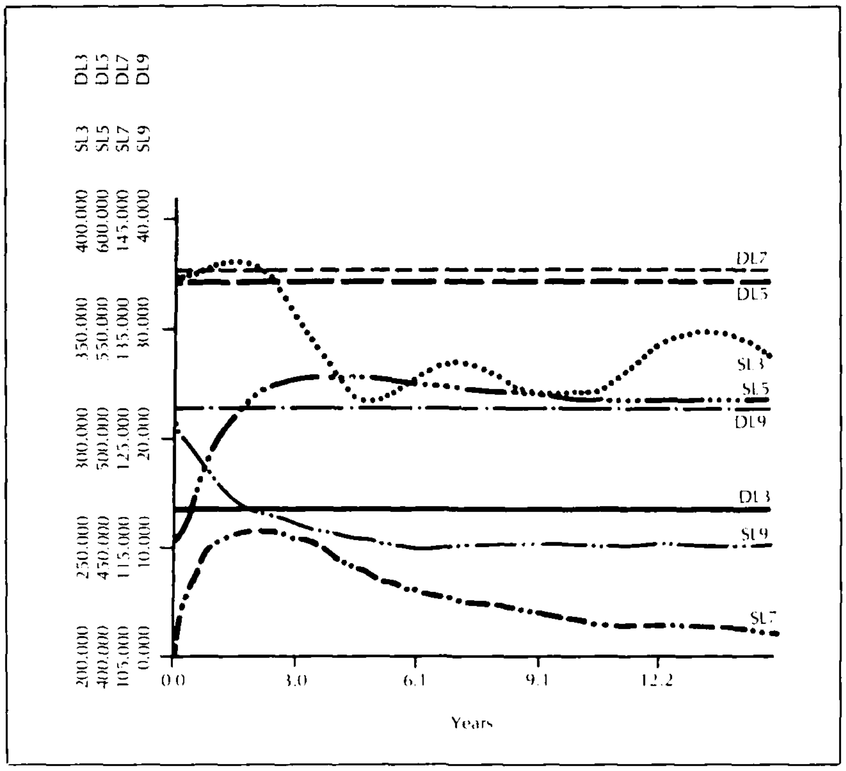

Figure 6. Increased desired number in skill levels: Personnel Fill Sector levels.

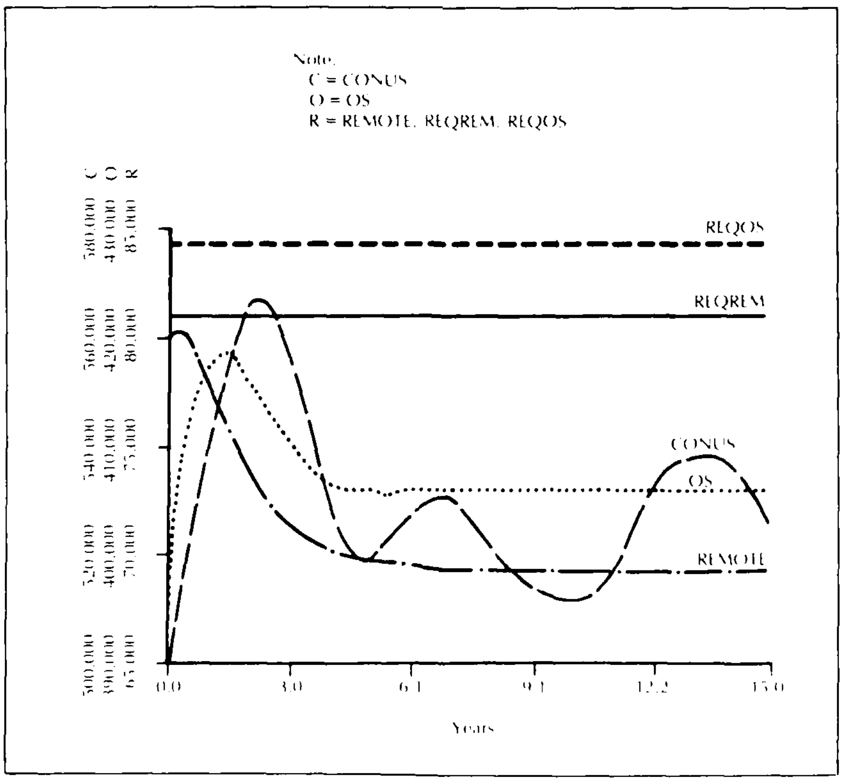

Figure 7. Increased desired number in skill levels: Rotation Sector levels.

CONCLUSIONS

The research reported in this paper focuses on the development of a dynamic policy model of the airman assignment and rotation system and the use of that model to investigate improved system performance under alternative policy formulations. The model was developed to facilitate study of system structural and parameter changes. It is being employed by Air Force policy-makers to evaluate the effects of policy changes.

The high-leverage policy discussed earlier involved increasing the stateside rotation by at least 15%. Current policies advocate converting military to civilian positions for jobs when vacancies arise. The test discussed here indicates that a larger military force in the continental United States is required. Conversion policies may not be the best for overall system performance. Policies which alter tour lengths or make minor changes in bonuses paid seem to have little effect on system performance. Those that expand the rotation base lead to the most favorable behavior.

The research methodology used, system dynamics, illustrates its advantage in such analysis. It provides an example of how complex flows through a variety of interconnecting levels can be modeled and how the model can be used in policy analysis. The conceptual structure of the system can be reflected in a formal model and easily conveyed to decision-makers. It is a parsimonious modeling technique that requires far less code and structure than entity models used for the same purposes. With such models, problems that arise in the system can be traced to their cause, and structural changes that would alleviate problems can be investigated and quickly tested.

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